STRUCTURE OF POPULATIONS OF OTATE (*OTATEA ACUMINATA* SUBSP. *AZTECORUM*: POACEAE) IN HARVESTED STANDS

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ABSTRACT

We describe the structure of eight natural stands of otate (*Otatea acuminata* (Munro) Cald. & Sod. subsp. *aztecorum* Guzmán, Anaya & Santana) that are subject to traditional extraction. These populations are compared based on density, diameter and height using growth stage categories, site characteristics and history of management. The point quarter method was used to sample populations to obtain estimates of stem densities. Analysis of variance was conducted on stem categories and density to compare stands; all comparisons showed significant differences between stands. Results suggest that the population structure of otate is being modified by harvest intensity, which appears to be a function of accessibility of the stands by basket makers and their history of use. Results are described in relation to harvesting otate for craft production.

KEY WORDS: Structure, otate, stem category, harvesting, artisan

RESUMEN

Se describe la estructura de ocho rodales naturales de otate (*Otatea acuminata* (Munro) Cald. & Sod. subsp. *aztecorum* Guzmán, Anaya y Santana) que están sujetos a extracción tradicional. Se comparan estas poblaciones de acuerdo a categorías de tallos, características del sitio e historial de manejo. Se utilizó el método punto cuadrante para estimar la densidad de tallos. Se hizo un análisis de varianza de la densidad y categorías de tallos para comparar los rodales entre sí; todas las comparaciones mostraron diferencias significativas en una o varias de las características evaluadas. Los resultados indican que la estructura de las poblaciones de otate está siendo modificada por la intensidad del aprovechamiento, el cual está determinado principalmente por la cercanía y accesibilidad de los rodales a los artesanos. Los resultados se discuten en relación al aprovechamiento para fines artesanales.

PALABRAS CLAVE: Estructura, otate, categoría de tallo, aprovechamiento, artesano

INTRODUCTION

Numerous genera and species of the Bambusoideae play an important role in forests because they occupy a wide diversity of habitats and exhibit extremes of morphological diversity (Soderstrom & Calderon 1974). The genera of bamboos in Mexico include: *Otatea, Olmeca, Guadua, Chusquea* and *Olyra* (Judziewicz et al. 1999). The antiquity of Bambusoideae species' use in Mexico is not known with certainty though we suspect its most ancient inhabitants used them. The bamboo otate (*Otatea* spp.) has been used in Mexico since prehispanic times for a wide variety of purposes including house construction, walking sticks, stakes, and for basket making, among others (Torres 1985; Anaya 1989; Benz et al. 1994; Bye 1995). Despite its long history of use and considerable study of its distribution and taxonomy, it is clear that information about the species' ecology and management is sorely lacking.

Otatea is a genus indigenous to Mexico and Central America, occurring in Pacific watersheds from Sonora to Chiapas and Central America, besides the Mexican states of Veracruz, Puebla, Queretaro and Mexico (Guzmán et al. 1984). There is a disjunct population in northeastern Colombia where it is called caña brava (Judziewicz et al. 1999). There are two species in the genus, *O. fimbriata* and *O. acuminata*, the last one with two subspecies, *O. acuminata* subsp. *acuminata* and *O. acuminata* subsp. *aztecorum*. These species are used for basket making, walk sticks, broom sticks, corral construction, canes, furniture, crop supports, and house rafters (Guzmán et al. 1984; Judziewicz et al. 1999).

This research was carried out in the ejido of Platanarillo, in the Municipality of Minatitlan in the Mexican state of Colima where otate (*Otatea acuminata* (Munro) Calderon & Soderstrom subsp. *aztecorum* Guzmán, Anaya & Santana) is an important natural resource. This subspecies occurs in the Mexican states of Sonora, Chihuahua, Sinaloa, Durango, Nayarit, Jalisco, Queretaro, Mexico, Guerrero y Puebla (Guzmán et al. 1984).

Otate forms dense thickets of erect, two to eight meter tall individual shoots whose apex often overarches surrounding vegetation. This species occurs mainly in gorges and on pronounced slopes, on thin and stony basic or acidic soils usually derived from calcareous rocks (Guzmán et al. 1984). Otate spreads asexually by rhizomatous growth. Young individuals are totally covered with culm leaves. Stems (culms) emerge annually in the humid season and reach their maximum height within three to four months. In Platanarillo, otate is used in house and corral construction but its principal utility and value is tied to its suitability for making handicrafts, principally baskets. There has been resurgence in local interest to promote large-scale extraction because of its market potential as a source of stakes for cultivation of tomatoes, chayotes and other vegetable crops.

Craft production in the ejido Platanarillo is of great socioeconomic importance because 32 families, or about 40 percent of the residents, engage in basket manufacture as a principal means of generating household income. Otate harvesting for this purpose has been carried out over the years under a traditional management scheme, that consists of the selective cutting of young stems. This traditional form of management is of considerable interest because these practices could have negative impacts on the re-

source because extraction frequently occurs repeatedly in the same areas and stands. The objective of this work is to describe how the structure of otate populations has been affected by traditional extraction.

STUDY AREA

The Ejido of Platanarillo is located between geographic coordinates 19°21' and 19°29' N latitude and 103°56' and 104°00' W longitude in the state of Colima. This ejido encompasses 3,028 hectares at an altitude ranging from 900 to 1800 meters above sea level. Nearly one-half of the ejido´s land area is located on the southwest flanks of Cerro Grande, a calcareous formation of sedimentary origin with 10 to 45 degree slopes. The remainder of the ejido is located on the north slope of the Sierra Perote, a volcanic formation with 25 to 45 degree slopes. Both form part of the northern-most extent of the Sierra Madre del Sur. Soils on the slopes of Cerro Grande are litosols and andosols, and on the Sierra Perote, regosols and cambisols (INEGI-SPP 1981).

Lithosols are generally shallow, rocky and infertile soils located in areas with pronounced slope. These soils are not particularly apt for agricultural purposes. Cambisols are superficial soils rich in organic material with weakly developed horizons found on moderate slopes. Nevertheless, cambisols are more appropriate for agriculture than lithosols. Andosols form from volcanic ash. They are very light textured and have a high capacity for retaining water and nutrients. This type of soil scarcely occurs in the study area, generally in areas with high slopes. Regosols are similar to cambisols in being rich in organic matter and having weakly developed horizons found on moderate slopes. They differ by regosols having almost no horizon development. Regosols support agricultural activities.

The climate in the area surrounding the ejido is mild, mid-latitude humid subtropical with dry winters and hot summers according to the modified Koeppen classification. Average annual precipitation is 1,350 mm. It presents a marked seasonality with a dry season from October to May and a wet season from June to September (Martínez et al. 1991). The predominant vegetation types in the ejido are the tropical deciduous forest, tropical sub-deciduous forest, and deciduous oak forest (Vazquez et al. 1995). Otate populations are an important component of the tropical deciduous forest that occupies the greatest extension in the ejido. These populations of otate occur mainly in communal land in the ejido, but also in areas with assigned rights, where basket makers must get permission for extracting the resource.

SAMPLING METHOD

Sites dominated by otate stands were delimited with aerial photos and a satellite image SPOT1 HRV2; band 321, scale 1:50,000 taken on March 30th of 1987 and ground truthing in the ejido. Otate populations occur over 340 ha in the ejido. An inventory of the otate populations was conducted during the months of May, June and November of 1993 to document the presence and evaluate the quality of stands.

A total of 25 individuals with an age ranging from 18 to 70 years helped in the inventory and were interviewed about the levels of extraction and harvesting intensity. Seven populations were selected on the calcareous soils of the flanks of Cerro Grande, and one was selected on the volcanic soils of Sierra Perote. These varied according with the harvesting intensity. Site characteristics were recorded for each stand in order to describe basic aspects of the sites where otate grows. These populations cover about 100 ha, almost a third of the total area with otate in the ejido. All of these populations have existed in the area during the last 30 years at least and remain today in spite of harvesting.

Estimation of stand density was calculated as the number of stems per hectare based on the point-quarter method of Cottam and Curtis (1956). Eight stands subject to different extraction levels were sampled systematically. Fifteen to twenty points were sampled in each stand. Points were placed on linear transects distributed systematically every 10 meters across each stand. The distance between points was established according to observed spatial pattern of the stand. Estimates of density were calculated using the equation proposed by Cottam and Curtis (1956): $D=dm^{-2}$ where: *D* is equal to density and *dm* is equal to the mean distance of stems from the center point in each quarter. Analysis of variance with multiple post-hoc comparisons using Duncan's method was used to compare population densities.

Culm diameter at breast height (dbh) was measured using a caliper. Height was measured using marked stakes. As stems reached their maximum height, they were classified into four growth-stage categories: new, young, adult and dead. New refers to stems that emerged during the last rainy season and were easily recognized by having complete spiculate culm leaves; young refers to those stems that had emerged two to three years ago, losing some culm leaves in the intervening time; adult stems refer to those with few or no culm leaves. Dead stems were easily recognized since they had neither foliage nor culm leaves and had brittle stems. Average age of shoot death was unknown. The average density of stumps (cut stems) was considered an indicator of the level of extraction and the average density of new stems was considered an indicator of regeneration.

Vigor was characterized in the following manner: good refers to green stems that are notably healthy, complete foliage; regular, yellowish stems and incomplete foliage with some damage; bad, refers to gray and cracked stems with irregular internodes with few, notably damaged leaves.

RESULTS

Population vigor varied from good to regular for new and young stems. Adult stems generally had regular vigor. Site characteristics were similar for stands located on the slopes of Cerro Grande while the single population on Sierra Perote was notably more favorable (Table 1, stand 8).

Stand eight exhibited the greatest regeneration and the highest density of stumps of sites with evidence of extraction. Stand six showed no evidence of extraction and the

TABLE 1. Site characteristics of eight otate stands in the ejido of Platanarillo.

Stand	Accessibility[1]	Area (ha)	Aspect	Slope in degrees	Rockiness[2]
1	Easy	10	Southwest	10–40	Medium
2	Easy	11	West	15–40	Medium
3	Moderate	19	West	15–45	High
4	Moderate	9	West	15–40	High
5	Difficult	8	Southwest	20–45	High
6	Difficult	4	West	20–35	High
7	Difficult	29	Southwest	20–45	High
8	Moderate	10	Northeast	25–45	Low

[1]Accessibility refers to distance, ease of transport and land tenure (communal or assigned rights). Easy access (within 20 minutes walk from the community, path with moderate incline and not rocky, communal land), Moderate access (between 30 and 60 minutes walk from the community, path rocky with moderate incline, assigned land rights limited to certain individuals), difficult access (greater than 60 minutes walk from the community, path rocky with steep incline, communal land)

[2]Rockiness refers to abundance and proximity of rocks (sediment > 1m in diameter) (Olvera et al. 1996). Low (absent to one rock every 20 meters), Medium (a rock every three to 10 meters), High (rocks predominate, soil barely visible).

lowest level of regeneration. Sites three and four exhibited intermediate levels of extraction and of regeneration (Table 2). Stands five and eight had the largest diameter of young, mature, and dead stems. Stands one, four and five had relatively large-diameter stems. Stands six and seven had small-diameter stems (Table 3). The tallest stems occurred in stands one and five; the shortest stems in stands two, three and seven (Table 4). Stand seven also had mostly small, short stems while stand eight had the tallest stems (Table 3 and 4).

In summary, stands number six and eight presented significant differences from the rest with respect to density, degree of extraction, and stem diameter. Stand eight exhibited the highest level of extraction, the greatest density of regeneration, and the largest—diameter and height—stems compared to the rest of the stands. In contrast, stand six exhibited no evidence of extraction, had the largest density of dead stems, showed the lowest density of regeneration, and had some of the smallest diameter stems (Tables 2–4).

According to our interviews with local basket makers, stands one and four were intensively extracted in the past. Stems are extracted from stands one and four by the greatest number of basket makers, with greatest regularity, each collecting between 40–60 stems per fortnight during September through November. Stands two, three and eight are subject to an intermediate level of extraction, at most ca. 40–60 stems per month. Stands five, six, and seven currently have the lowest levels of harvesting, the equivalent or less of 10 stems per month.

TABLE 2. Density (mean and standard deviation) of stems ha^{-1} in eight stands of Otate in the ejido of Platanarillo, Municipio of Minatitlan, Colima, Mexico. Stands with the same letters are not significantly different at $p<0.05$.

	Stands							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
New	2309±2556 bcd	2582±1391 bcd	3140±1193 cd	2671±2646 bcd	2618±3283 bcd	1206±1266 abc	966±999 ab	3131±1845 cd
Young	1412±1302 abc	2411±2463 abcd	3556±2599 bcde	2911±2922 abcde	4810±2603 cde	4871±3210 cde	3557±3789 bcde	3365±1416 bcde
Adult	4025±6057 abcde	2089±2141 abc	4550±6686 abcde	3081±3306 abcd	6480±3623 abcde	8227±6393 cde	5472±6352 abcde	6993±8984 bcde
Dead	1304±1065 abc	4402±6397 abcde	5270±4653 abcde	3106±3463 abcd	7614±9690 bcde	9556±9355 cde	8000±9999 cde	4144±2443 abcd
Stumps	2424±3238 abcde	1551±2177 abc	2898±3981 abcde	4257±4789 acde	968±1894 abc	*	414±688 abcd	4685±3987 cde

*No stumps

TABLE 3. Diameter at breast height of stems (in cm, mean and standard deviation) in eight stands of otate in the ejido of Platanarillo, Municipio of Minatitlan, Colima, Mexico. Stands with the same letters are not significantly different at $p<0.05$.

	Stands							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
New	2.5±0.56 bcd	2.4±0.61 bc	2.±0.67 bc	2.9±0.64 de	2.7±0.69 cde	2.4±0.64 bc	2.0±0.70 a	2.8±0.76 de
Young	2.6±0.60 def	2.3±0.59 bcd	2.3±0.62 bcd	2.4±0.63 bcdef	2.6±0.79 def	2.0±0.79 a	1.8±0.77 a	3.0±0.84 g
Adult	2.2±0.39 cd	2.0±0.42 bcd	2.0±0.54 bcd	2.1±0.48 cd	2.3±0.63 cd	1.8±0.64 bc	1.4±0.60 a	2.8±0.78 e
Dead	2.3±0.47 de	1.9±0.43 abc	1.8±0.43 abc	2.1±0.62 cde	2.0±0.61 bcd	1.7±0.42 abc	1.5±0.57 ab	2.6±0.76 f

TABLE 4. Height (in meters, mean and standard deviation) of otate stems in eight stands in the ejido of Platanarillo, Municipio of Minatitlan, Colima, Mexico. Stands with the same letters are not significantly different at $p<0.05$.

	Stands							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
New	4.09±1.14 bcd	4.23b±1.2 cd	3.90±1.14 abc	4.92±1.03 def	5.50±1.64 ef	5.08±1.66 ef	3.55±1.45 ab	4.52±1.55 cde
Young	3.71±0.97 cd	2.97±0.91 bc	3.02±0.89 bc	3.31±0.79 bc	4.13±1.09 e	3.35±1.19 bcd	2.42±1.03 a	3.25±0.84 bc
Adult	2.92±0.79 cd	2.46±0.71 bc	2.45±0.82 bc	2.82±0.65 cd	3.47±0.95 e	2.67±0.90 bcd	2.01±0.84 a	2.88±0.67 cd
Dead	2.85±0.76 c	2.28±0.73 b	2.33±0.79 b	2.73±0.70 c	3.23±1.08 d	2.75±0.64 c	1.88±0.78 a	2.64±0.63 c

DISCUSSION

Harvesting in the ejido is based on selection of young stems because these make better, more flexible, baskets. Over the years, this kind of management has produced a stand structure with an abundance of adult stems and appears to promote regeneration.

Field observations indicated that stands one and four have the greatest proliferation of woody species (*Acacia* spp. and *Lysiloma* spp.) and these stands have some of the lowest densities of young, adult, and dead stems. According to local informants these two sites were once occupied by dense stands of otate that were intensely exploited in the past, suggesting that prolonged and intense extraction impeded regeneration of adult stems in these otate populations and permitted the invasion and establishment of trees and shrubs. This intense harvesting of sites one and four during the past was due mainly to their proximity to the communities inhabited by a large number of basket makers.

On the other hand, stand eight appeared to respond to high levels of extraction by producing a high density of new large-diameter stems. This could be due either to high levels of extraction reducing competition or its location on rock-free acidic soils with high fertility. Stand six had the lowest level of regeneration—it had the highest density of mature and dead stems—perhaps because the population has not been subject to thinning by basket makers extracting stems for basketry manufacture. These results lead us to hypothesize that the basket makers of Platanarillo have exceeded sustainable levels in some stands (one and four) while maintaining appropriate levels of extraction in others (two, three, five, seven and eight) appropriate to ecological conditions and the population's ability to regenerate.

Numerous hypotheses have been offered to explain massive flowering of bamboos. This phenomenon (gregarious monocarpy) might be determined by physiological changes caused by growing conditions, attempts to satiate seed predators, the intensity of extraction or by perturbation like wildfire or similar factors (Janzen 1976; Keeley & Bond 1999). The flowering periodicity of these otate populations is known from local folklore (Santana & Lemus 1992). According to local people, the last massive flowering event occurred 30 to 35 years ago. Seven informants between 40 and 55 years old report having seen the flowering process once before, and two informants, 75 and 80 years old, have seen it flower twice before.

In 1993 we observed a few culms flowering in some otate populations of the ejido, but not all individuals in a stand appeared to flower simultaneously. Widely separated individual culms flowered while nearby culms did not. Within one year's time from the appearance of one flowering individual, all individuals will have flowered. Now, in the year 2000, most of the populations have flowered completely. Nevertheless, the flowering process has been sequential and prolonged, not simultaneous; some populations still have not flowered. By the time the last population in the ejido flowers, the first population to flower will have new shoots that can be extracted for basket manufacture. The flowering process in the ejido requires a period of about seven years to be completed. If

our observations about the flowering process are accurate, we suspect that extraction for basket manufacture has little or no impact on flowering process.

CONCLUSIONS

Continuous harvesting of young stems from stands three, five, six, seven, and eight appears to be possible from the information we have obtained thus far. These stands had either a high density of regeneration (stand three) or had high densities of young and adult stems (stands five, six, and eight). Stand seven had the lowest level of regeneration, so, the extraction of new stems here must be the lowest. There is an obvious need to reduce extraction in stands one, two, and four, all of which have been intensively exploited in the past and exhibit densities of young and adult stems that suggests high regeneration rates.

It appears contradictory that population six located at the greatest distance from the largest number of basket makers possesses the poorest quality for basket manufacture, while population eight located closest to a significant number of basket makers exhibits the greatest intensity of extraction, hast the greatest amount of regeneration and possesses stems with greatest useful dimensions. We offer the working hypothesis that human extraction of otate stems in Platanarillo has actually fostered growth of more stems with better qualities.

Otate is a very important resource for the ejido, especially for the poor people (most of the ejido´s inhabitants) because of its utilitarian and economic value. Commercial extraction poses management challenges because the intensity of extraction could be considerably greater than potential regeneration, while labor investment and the immediate economic benefits are significantly higher than actual costs.

Suggestions For Management

A controlled management program must be implemented in order to regulate harvesting practices. Basket makers agree that regulation of extraction is necessary and propose some actions of control, like protection against fire, excluding livestock, and commercial harvesting of adult stems. Establishment of permanent research plots is also necessary in order to continuing monitoring and evaluating the populations' responses to different harvesting treatments. These measures could lead to improved management by establishing cutting level as well as a systematic registration of the phenology of the species. This will be very important since the process of flowering is nearly complete in all populations of the ejido. The monitoring process should involve local people and trained investigators.

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